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Does the Craniolateral Approach Provide Better Exposure to the Radius than the Craniomedial Approach for Internal Fracture Fixation in Dogs?

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Abstract

Objectives To compare the exposure of the craniolateral approach (CLA) with craniomedial approach (CMA) of the radius in dogs. To make general observations of each approach that may affect the ease of fracture repair.

Study Design Six canine cadavers were used in the study to compare the exposed surface area, length, and width of radius with CLA and CMA ($n = 12$).

Results The CLA exposed a larger surface area of the radius compared with the CMA ($p = 0.01$). The CLA of the radius had greater proximal width compared with the CMA ($p = 0.01$). There was no significant difference in the length of exposed radii with either approach.

Conclusion The CLA provided greater exposure for internal fixation of the radius in dogs.

Keywords

- canine radius
- fracture repair
- craniolateral approach
- craniomedial approach

Introduction

Fractures of the radius and ulna bones account for 17% of all dog fractures, making them the third most common site of fracture.[1] Fractures in the distal third of the radius are common in small breed dogs.[2] Radial and ulnar fractures in large breed dogs compared with small breed dogs frequently are in the mid-shaft, are commonly comminuted, and require additional proximal surgical exposure for plate fixation.[3] Open reduction and internal fixation is a frequently used surgical procedure for treating fractures of the radius.

The reported surgical approaches to the radius include lateral, craniolateral (CLA), craniocaudal, medial, craniomedial (CMA), and caudomedial approaches.[4] Many veterinary surgeons use a craniomedial surgical approach with cranial plating, due to the tension side of the radius being cranial.[4,5] Furthermore, cranial plating has been advocated with minimally invasive plate osteosynthesis.[6–13] When applying a bone plate to the cranial surface of the radius, surgeons must navigate around the cephalic vein and the extensor carpi radialis tendon. Retracting the extensor carpi radialis laterally to expose the radius can cause underreduction of the fracture, leading to valgus and external rotational malalignment of the limb.[14] Placement of the plate cranially, below the extensor carpi radialis tendon, can lead to tendon irritation.[14] However, with meticulous technique, those very rare concerns can be avoided, as has been shown in many publications.[9,10,14,15]

Medial plating of the radius via a medial surgical approach was successful in 22 small and large breed dogs and cats and reported to be a less difficult approach than the traditional CMA and repair.[14] One challenge of the medial plating is the in-plane contouring of the standard nonlocking or locking bone plates, to accommodate the natural procurvatum of the radius . Plates spanning only half of the radius will require minimal in-plane contouring. Another challenge of medial plating of the radius is that the most proximal aspect of the radius is more difficult to expose, and neurovascular structures will be encountered and need to be preserved.

Tension side plating of the radius, as indicated from Wallace's biomechanical study, is not necessary and validates consideration of other surgical approaches to the radius.[16]

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The purpose of this study is to compare the bone exposure of the traditional surgical CMA with the CLA. We hypothesized that the CLA provides greater exposure to the radius than the CMA for plating.

Materials and Methods

Study Design

Animals

Six mixed-breed and skeletally mature canine cadavers consisted of three males, one neutered male, and two female dogs with unknown reproductive status. The mean weight of the canine cadavers was 23.8 kg (range: 18.5–38). The cadavers were obtained from a local animal control center, and we obtained full permission from them to use them for our research study.

Exclusion Criteria

Lateral and craniocaudal orthogonal radiographs of the left and right forelimbs were made to rule out fractures, aggressive bone lesions, and asymmetry of the radii.

Preparation

The frozen cadavers were thawed for a minimum of 48 hours at room temperature before collecting any data. Hair was removed from both forelimbs using clippers. Randomizing forelimbs for CMA or CLA involved a coin flip.

Approaches to the Radius

Craniolateral Approach

A craniolateral antebrachial skin incision was made with a scalpel from the proximal end of radius to the carpus along the muscular furrow between the extensor carpi radialis and common digital extensor, lateral to the cephalic vein. The deep antebrachial fascia was incised between muscle bellies and tendons of the extensor carpi radialis and common digital flexor. The abductor pollicis longus was transected on the lateral aspect of the radius (►**Fig. 1**). The attachment of the supinator muscle was sharply incised along its lateral and distal borders and elevated to expose the proximal radius. Gelpi retractors (not shown in ►**Fig. 2**) were placed between the extensor carpi radialis and common digital extensor to maintain exposure of the radius (►**Fig. 2**).

Craniomedial Approach

A skin incision was made with a scalpel on the craniomedial aspect of the antebrachium from the level of the proximal end of radius to carpus, medial to the extensor carpi radialis muscle and tendon. The cephalic vein was preserved as it traversed the distomedial surface of radius. The deep fascia between the extensor carpi radialis and the pronator teres was incised. The tendon sheath was incised along the medial and lateral borders of the extensor carpi radialis tendon. The medial and distal aspects of the supinator muscle attachment to the radius was elevated to expose the proximal end of radius. Gelpi retractors (not shown in ►**Fig. 3**) were placed to retract the extensor carpi radialis muscle and tendon laterally to expose the radius (►**Fig. 3**).

Data Collection

A latex sheet cut from a surgical glove (ENCORE, Ansell) was placed on the exposed radius, and a black marking pen was used to trace around the borders of the exposed radius for both CMA and CLA. The template was cut from the rubber sheet. To ensure accuracy of size and shape, the rubber

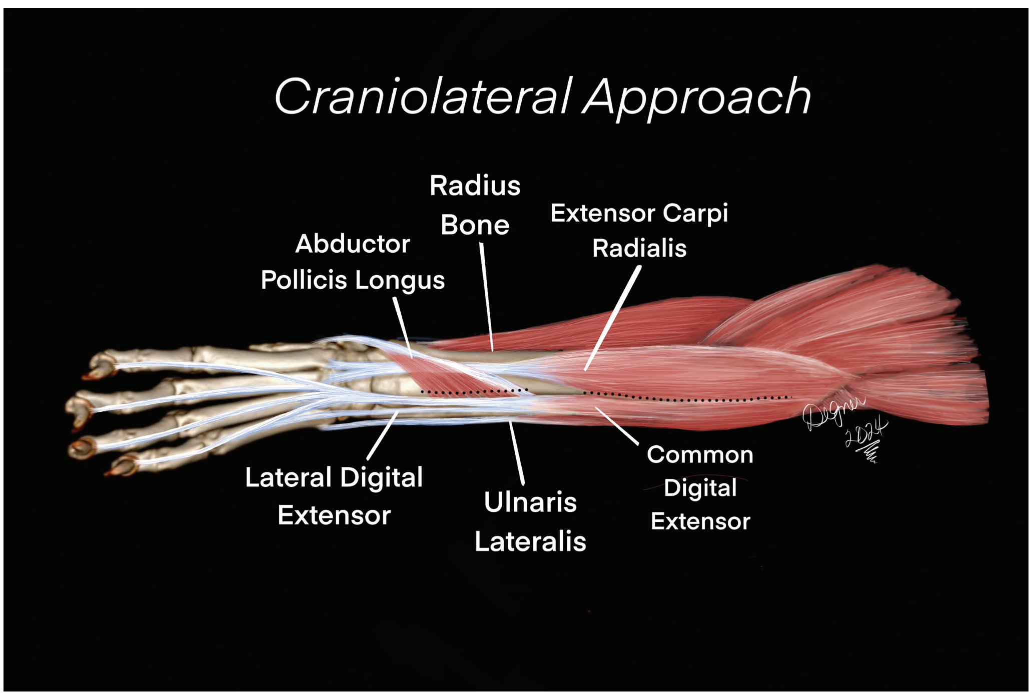

Fig. 1 Cranial view of the left forelimb. The dotted lines depict the separation of the extensor carpi radialis and the common digital extensor and transection of the abductor pollicis longus in the craniolateral approach.

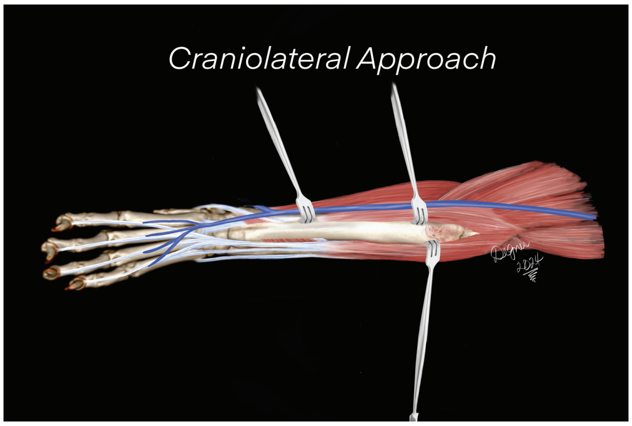

Fig. 2 Cranial view of the left forelimb. The craniolateral aspect of the radius was exposed following the separation of the extensor carpi radialis and common digital extensor, transection of the abductor pollicis longus, and elevation of the supinator muscle in the craniolateral approach.

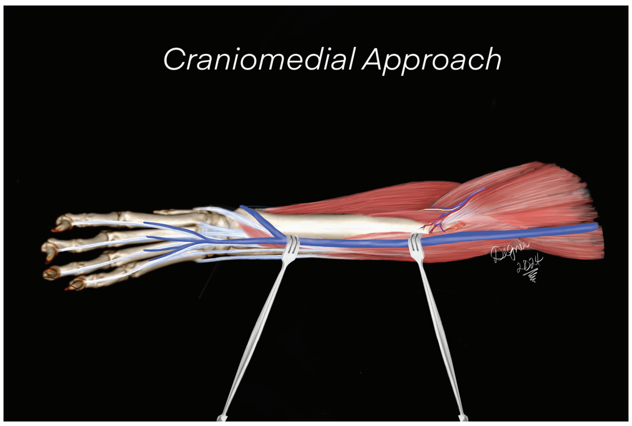

Fig. 3 Cranial view of the left forelimb. The cranial aspect of the radius is exposed with the craniomedial approach with lateral retraction of the extensor carpi radialis.

template was placed back onto the exposed radius (►**Fig. 4**). The templates from left and right limbs and a measuring caliper (Aratana Therapeutics, Kansas) were placed on a flat surface and photographed (►**Fig. 5**). The images were analysed with ImageJ 1.53. The set scale function was used to calibrate pixels into centimeters using the 1-cm length on the caliper in the image. The surface areas of the templates were obtained by measuring around the edge of the piece with the freehand selection function. Three surface area measurements were taken for each template.

Length of Canine Radius

The radiographs were standardized using a 10-cm calibration bar (BioMedtrix, St. Augustine, United States). The anatomic axis was drawn on the radius on the craniocaudal view, and the bone length was measured from the proximal to distal articular surfaces using image viewing software (Horos, Osirix) measuring tool. The Horos software has a built-in calibration for radiographic measurements.

Length of Exposed Canine Radius

A line was drawn from the lateral to the medial edge as proximally as possible on the template, the same is repeated distally. A line was drawn from the midpoint of the most proximal end to the midpoint of the most distal end of the template using ImageJ (National Institutes of Health, Bethesda, Maryland, United States).

Width of Exposed Canine Radius

A line drawn at 50% of length and width was measured (M). The width was measured at 6.25% intervals of the total length of template from the most proximal end to M, the same was repeated from the most distal end to M. The measurements from the most proximal and distal end to M was at 6.25% (P1, D1), 12.5% (P2, D2), 18.75% (P3, D3), 25% (P4, D4), 31.25% (P5, D5), 37.25% (P6, D6), and 43.75% (P7, D7) of total template length.

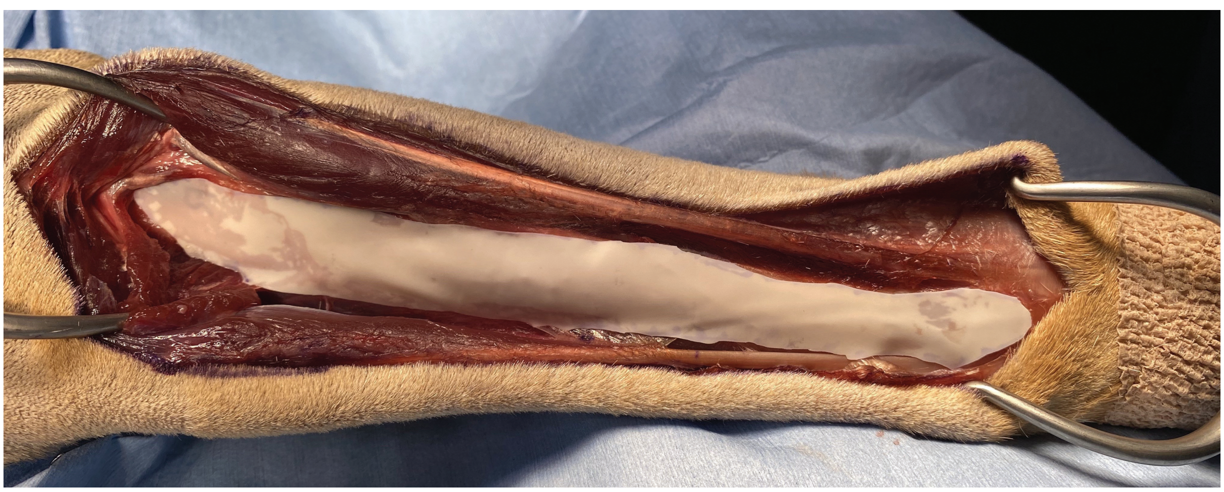

Fig. 4 Cranial view of left antebrachium (paw is to right). The latex template was laid over the exposed bone after completion of the craniolateral approach to ensure the accuracy of exposed bone measurement.

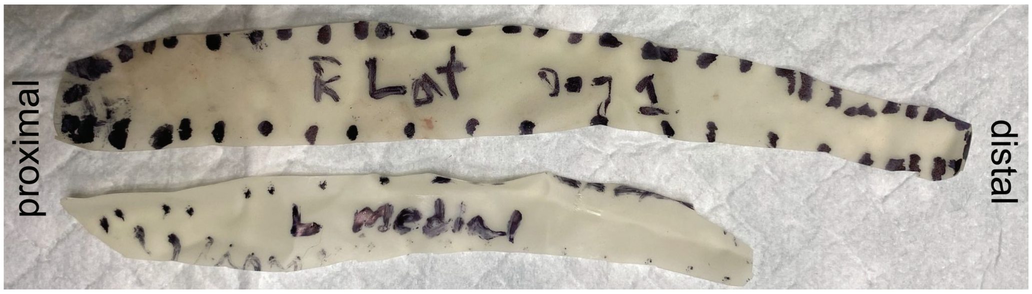

Fig. 5 Exposed radius craniolateral approach (top) and craniomedial approach (bottom) templates depicting a significantly larger area of exposed bone for the craniolateral approach.

Statistical Analysis

Three surface area measurements obtained from each piece were averaged. The CLA and CMA surface area, length on orthogonal view of radiographs, length and width of exposed radii of all six dogs were calculated as a mean. All the statistical analysis was performed with *t*-test with paired two samples for means, defining $p < 0.05$ as statistically significant.

Results

Radiographs

Both lateral and craniocaudal views of left and right forelimbs of cadavers were symmetrical. No fractures, deformity, or short radius syndrome were seen.

Length of Radius on Craniocaudal View of Forelimb Radiographs

Amongst cadavers, the average difference between left and right forelimb radial length was 0.1 cm (range: 0–0.4). The length of radius was 16.5 ± 3.5 and 16.6 ± 3.3 cm of the left and right forelimbs, respectively, and no significant statistical difference between limbs was found ($p = 0.38$).

Surface Areas of Canine Radius

The average surface area of the exposed radius with the CMA ($13.8 \pm 3.2\ cm^2$) was less than with the CLA ($19.4 \pm 4.7\ cm^2$; $p = 0.01$).

Length of Exposed Canine Radius

The length of the exposed radius for the CMA (11.4 ± 2.8 cm) and the CLA (12.9 ± 1.4 cm) were not significantly different ($p = 0.08$).

Width of Exposed Canine Radius

The width of exposed canine radius with the CMA at P2 (1.2 ± 0.2 cm) was significantly less than the CLA (1.4 ± 0.3 cm; $p = 0.01$). The remaining width measurements were not statistically significant between CMA and CLA (**►Table 1**, **►Fig. 6**)

General Observations Noted in All Dogs

Proximally, the extensor carpi radialis muscle belly was much more easily retracted medially rather than laterally; thus, perpendicular access to the radius was achieved in the CLA. Branches of the radial nerve that innervate the antebrachial extensors were not encountered proximally between the extensor carpi radialis and common digital extensor bellies in the CLA. With elevation of the lateral aspect of the supinator during the CLA, neurovascular bundles were not encountered at the proximal radius within 1 cm of the articular surface. In contrast, a neurovascular bundle (median nerve/artery/vein) was always encountered with proximal exposure of the radius during the CMA. The CMA mandated liberation of the extensor carpi radialis tendon from its sulcus with lateral retraction. The proximal

Table 1 Proximal width measurements for exposed radius

	CMA		CLA		
Location of measurement	Exposed width of radius (cm)	± Standard deviation (cm)	Exposed width of radius (cm)	± Standard deviation (cm)	*p*-Value
P1	0.89	0.22	1.15	0.25	0.077
P2	1.16	0.21	1.39	0.31	0.016
P3	1.35	0.25	1.53	0.35	0.222
P4	1.5	0.28	1.59	0.38	0.527
P5	1.55	0.31	1.67	0.39	0.476
P6	1.55	0.35	1.77	0.39	0.29
P7	1.52	0.3	1.8	0.38	0.116

Abbreviations: CLA, craniolateral approach; CMA, craniomedial approach.

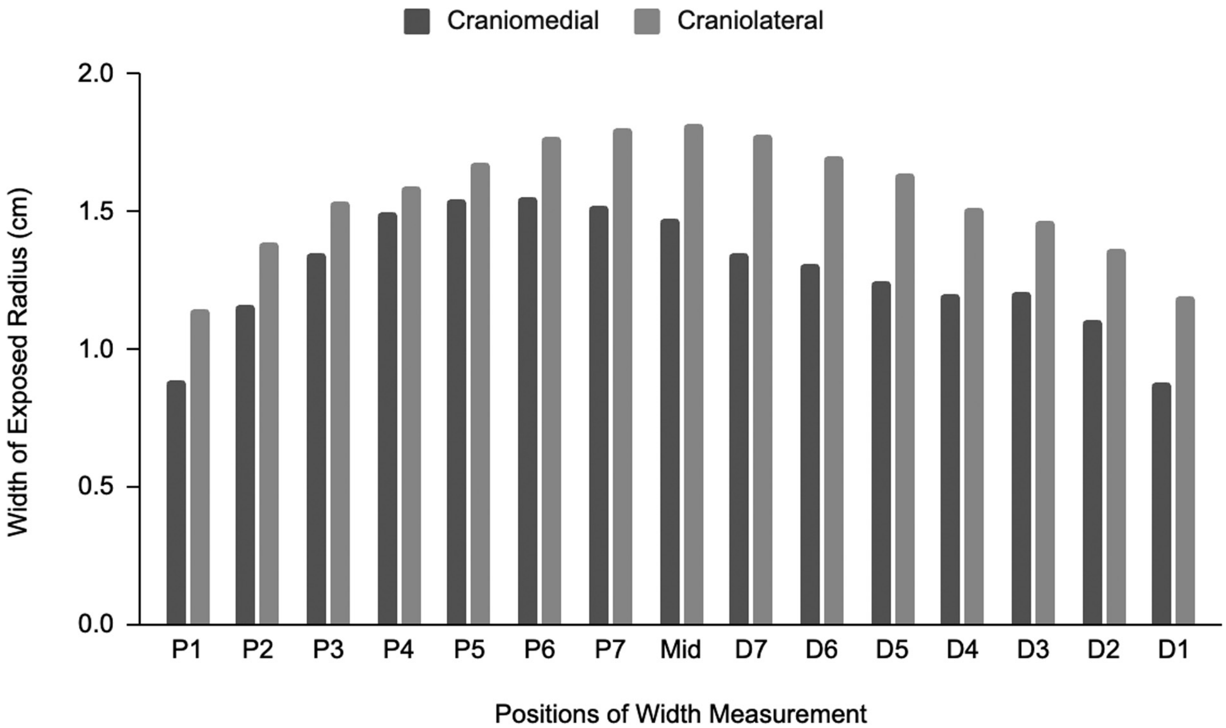

Fig. 6 Width measurements of exposed radius for craniomedial approach and craniolateral approach.

surface of the radius on all dogs was tilted laterally. The distal portion of the radius had a flat cranial face and a flat craniolateral face.

Discussion

The radius had more exposed surface area of CLA compared with the CMA. One of the CLA proximal measurements had larger exposure, which can be explained by a lack of neurovascular bundles present in the area. The CLA had wider exposure proximally than the CMA. The width of bone exposure in both the CLA and CMA was adequate for the placement of a bone plate of appropriate size.

Based on the overall larger exposed surface area with the CLA compared with the CMA, the former might provide better visualization of the bone fragments during surgery and therefore allow more precise reconstruction of the bone. However, as this was a cadaveric study, and the effect of soft tissue retraction as well as surgeon experience could not be included, a clinical study comparing those approaches in bones with similar fracture patterns is needed to examine, if our findings have any clinical importance. A potential number of benefits of the CLA exist. The craniolateral aspect of the radius has a corridor that is relatively free of tendons aside from the abductor pollicis longus, which obliquely crosses the radius. This muscle must be transected distally to allow for plate placement; however, the proximal aspect of the muscle and its tendon may be preserved by placing the plate beneath it. There is little evidence to suggest that a transected abductor pollicis longus in dogs would have any clinical impact. One case report reported the development of carpal osteoarthritis following transection of the abductor pollicis longus in a dog. However, it is uncertain if this association is true for all dogs.[17] Extensor carpi radialis is an important extensor tendon of the carpus, irritation must be avoided during bone plating. Abductor pollicis longus is a minor tendon to the first digit of manus and therefore is unimportant to the overall function of canine manus.

The distal radius has two faces: the cranial face and the craniolateral face. The extensor carpi radialis runs along the cranial face of the radius, where cranial plating may be necessary. Distally placed plates on the cranial surface encroach on the extensor carpi radialis tendon sheath and the sulcus where the extensor carpi radialis lies. The placement of a plate on the craniolateral aspect of the radius avoids tendon interference and may have other advantages. Screws inserted obliquely across the bone increase screw purchase and the strength of the bone–plate construct.[16] Placing a plate on the craniolateral surface of the bone can reduce the risk of a surgically induced valgus deformity, because the flat surface of the plate is juxtaposed to the bone. In addition, retracting the extensor carpi radialis medially may help to collapse the medial fracture gap, minimizing valgus deformity.[14]

Minimally invasive plate osteosynthesis is beneficial for radial fractures in large breed dogs, as these fractures tend to be comminuted and require a long plate spanning the length of the radius. The CLA principles may also be applied to minimally invasive plate osteosynthesis by making small proximal and distal incisions along the same tissue planes. A challenge with locking plates used in minimally invasive plate osteosynthesis is the perpendicular placement of the locking drill guide to the plate in a limited and deep surgical approach. The CLA provides good vertical access to the proximal radius, whereas the CMA does not.

A reported benefit of medial plating is the avoidance of placing screws through both the radius and ulna bones, a potential complication of cranial plating.[14,15] Similarly, with CLA, screws directed in a craniolateral to caudomedial direction may also avoid engaging the ulna bone, except in the most proximal region of the antebrachium. However, with appropriate planning and intraoperative measurement, this complication is often a technical error and cannot be related to the approach. The proximal cranial surface of the radius is tilted laterally; thus, with cranial plate application, the proximal aspect of the plate should be twisted laterally, in addition to a cranial contour over the mid radius to accommodate for the natural procurvatum of the radius.[18] With craniolateral plating, minimal twisting of the proximal plate may be needed. Cranial bowing of the plate will likely still be needed and should be based on a preoperative lateral oblique radiograph of the contralateral limb positioned to highlight the craniolateral surface.

With the CLA, internal fixation of the ulna can be achieved without requiring a separate incision on the skin. A deep fascial incision and retraction of the flexor carpi ulnaris and ulnaris lateralis provides good exposure to the ulna bone. The CMA would require a separate skin incision to repair a concurrent ulnar fracture.

Limitations of this study primarily include small numbers of samples and use of cadavers. Cadaveric tissue is more pliable than living tissue that has been previously injured days prior to surgery. This may have increased the exposure to the bone artificially in our study. We only used large breed dogs, assuming similar muscle anatomy in small breeds for CLA utilization.

In summary, the CLA has many advantages over the CMA for the repair of antebrachial fractures in dogs.

Authors' Contribution

K.T.L.: concept—lead; data curation—lead; study design—lead; data analysis and interpretation—lead; revising and draft—lead. D.A.D.: concept—lead; data curation—equal; study design—lead; data analysis and interpretation—partial; revising and draft—equal. C.E.D.: concept—partial; study design—partial; revising—partial.

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Conflict of Interest

None declared.

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